**Experiment 2: Measurement of *g***

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**(2.) Derivation**

We start with the equation for velocity . We will refer to the distance between the two photogates as and we will call the distance between the bottom photogate and the impact sensor The time corresponding times will be referred to as and . We attain the following equations for each average velocity:

The average time that the ball spent between the two photogates can be found by taking the average of the two times:

Acceleration is given by the equation . We substitute , , and into this equation.

**(3.) Plots**

**Figure 1:** This plot contains data from dropping a ball between photogates and onto an impact sensor. After computing the standard error for the slope and intercept, the value of the slope is (0.5699 ± 0.1904) s-2, and the value of the intercept is (10.10 ± 0.08277) m/s2. The distance measured for each trial was the distance between the bottom photogate and the impact sensor.

Given that acceleration due to gravity has a value of 9.80 m/s2, I expected the values of gravity to be near that value, regardless of the value of the distance between the bottom photogate and the impact sensor. My expectation of consistency in the value of gravity would have produced a horizontal trendline. Instead, the actual trendline indicates that the value of gravity depends on the value of the distance. Our data suggests that as the distance traveled by the falling object increases, the value of the acceleration due to gravity decreases.

In order to see how well the trendline fits the data, we will run a regression data analysis. The regression produced an R2 value of 0.749. This value indicates how well the linear regression fits the data. An R2 value close to 1 indicates very strong representation of the data. Alternatively, regression that produce R2 values closer to 0 do not fit the data well. Because our R2 value is 0.749, we cannot rule out the linear model for this data set. However, given more data points with higher values for *D*, we would be able to see whether the data continues to decrease, or whether it converges to a specific value.

**Figure 2:** This is a plot of the same data points, but it uses the power model instead of a linear model. The equation for the trendline indicates that the data converges at a value of 9.648 m/s2.

The linear model implied that the value of the acceleration due to gravity continues to decrease as the distance between the bottom photogate and the impact sensor increases. The power model provides a more reasonable result, which is that the gravity converges to a certain value. While the linear model fits the data well, the power model seems to fit the data better. For reference, the R2 value for this power model is 0.885, which is significantly higher than the linear model’s value of 0.749.

**Figure 3:** \*\*\*

**(4.) Data Tables**

|  |  |  |  |
| --- | --- | --- | --- |
| Trials | Photogate Separation *d* (m) | Photogate to Sensor Separation *D* (m) | Acceleration due to gravity (m/s2) |
| 1 | 0.089 | 0.152 | 10.111 ± 0.12 |
| 2 | 0.089 | 0.230 | 9.8982 ± 0.055 |
| 3 | 0.089 | 0.373 | 9.8453 ± 0.055 |
| 4 | 0.089 | 0.522 | 9.7747 ± 0.025 |
| 5 | 0.089 | 0.676 | 9.7668 ± 0.021 |

**Figure 4:** for the balls

|  |  |  |
| --- | --- | --- |
| Trials |  |  |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**Figure 5:** for the comb

**(5.) Conclusion**

**(6.) Extra Credit**

**Presentation Mini-Report**